

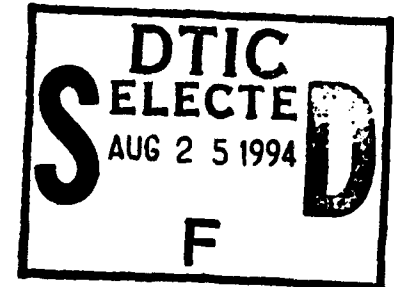
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## Committee on Tidal Hydraulics

### Minutes of the 102nd Meeting



31 August-2 September 1993

#### Executive Summary

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The 102nd meeting of the Committee on Tidal Hydraulics was held at the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, on 31 August through 2 September 1993. The tidal hydraulics-related research program of WES was the primary focus of the meeting.

Program managers presented overviews of the Dredging Research Program, Environmental Effects of Dredging, Wetlands Research Program, and the program to protect sea turtles from dredge hazards. Principal investigators described individual program research efforts on short- and long-term fate of dredged material, fluid mud definition, shoaling reduction through use of a current deflector wall, and hydraulics of wetlands sites in Louisiana.

Site-specific studies were presented for Long-Term Management of Dredged Material in San Francisco Bay, Houston-Galveston Navigation Channels, Delaware Bay, Chesapeake and Delaware Canal, New York Bight, Coast of Delaware, and Barnegat Inlet.

The design of a proposed large-scale flume for unsteady, nonuniform flow and transport research, the ESTEX Hyperflume, was presented for Committee critique. A computer-based tidal hydraulics bibliographic system, Landsat/Geographic Information System delineation of sediment plumes, and a numerical modeling workstation were demonstrated.

During the Executive Session, the Committee provided comments on the Research and Development efforts presented and reviewed progress on the Cohesive Sediments Newsletter, Tidal Hydraulics Workshop, and Committee pamphlet.

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# Minutes of the 102nd Meeting

## 31 August-2 September 1993

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1. The 102nd meeting of the Committee on Tidal Hydraulics (CTH) was held 31 August-2 September 1993 in Vicksburg, MS, at the invitation of Mr. Frank A. Herrmann, Jr., Director of the Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station (WES).

2. On 31 August and 1 September, Technical Sessions were held on WES research projects. On 2 September 1993, the CTH held an Executive Session.

3. Attendance at the 102nd meeting was:

### Committee on Tidal Hydraulics

Mr. Frank A. Herrmann, Jr., Chairman  
Mr. William H. McAnally, Jr., Executive Secretary  
Mr. Samuel B. Powell, Liaison

Mr. H. Lee Butler  
Mr. John G. Oliver  
Ms. Virginia R. Pankow  
Mr. Edward A. Reindl, Jr.  
Mr. A. David Schuldt

### Consultants

Dr. Donald W. Pritchard

Waterways Experiment Station  
Waterways Experiment Station  
Headquarters, U.S. Army Corps  
of Engineers  
Waterways Experiment Station  
North Pacific Division  
Water Resources Support Center  
Galveston District  
Seattle District

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DTIC	<input type="checkbox"/>
TAB	<input type="checkbox"/>
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Professor Emeritus, State  
University of New York at  
Stony Brook

Dr. Ray B. Krone

Mr. Henry B. Simmons

Chairman Emeritus, University of  
California at Davis  
Vicksburg, MS

#### **Other Corps of Engineers Representatives<sup>1</sup>**

COL Bruce K. Howard

Mr. A. Jay Combe

Dr. Michale Gee

Mr. Glenn A. Pickering

Dr. R. Charlie Berger

Mr. Allen M. Teeter

Dr. Rob McAdory

Mr. Joseph V. Letter

Mr. Glenn Rhett

Dr. T. M. Parchure

Dr. Ming Tseng

Dr. Billy H. Johnson

Mr. David J. Mark

Dr. Norman W. Scheffner

Mr. E. Clark McNair

Mr. Thad C. Pratt

Mr. Thomas R. Patin

Dr. Lyndell Z. Hales

Ms. Katherine M. Kennedy

Mr. C. Steve Jones

Dr. Gregory Nail

Mr. William C. Seabergh

Mr. Michael P. Alexander

Mr. William L. Boyt

Ms. Barbara P. Donnell

Waterways Experiment Station

New Orleans District

Hydrologic Engineering Center

Waterways Experiment Station

Waterways Experiment Station

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Waterways Experiment Station

Headquarters, U.S. Army Corps  
of Engineers

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#### **Other Agencies<sup>1</sup>**

Mr. Michael O'Hargan

Mr. James Hubbard

National Ocean Service

National Ocean Service

4. The minutes are divided into discussions of presentations made at the Technical Sessions and actions taken at the Executive Session. The order of the minutes is not necessarily the chronological order in which these matters were considered at the meeting.

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<sup>1</sup> Attended Technical Sessions only.

## Technical Sessions

5. Colonel Bruce K. Howard, Commander, WES, welcomed the CTH and guests. He noted that the long history of the CTH is a tribute to its success and contributions to the U.S. Army Corps of Engineers (USACE). There is now a different mix of concerns for the USACE and Nation than at the CTH's founding—Army needs for concerns around the world, for example in Somalia and Russia, and increased environmental concerns often strain the technical capabilities of the Army. He stated that the WES program is now about \$350 million, up dramatically over past years, but the number of WES people to handle that program has been about constant over the past few years. That imbalance will strain WES's capability to get the work done, but it will be done.

6. Mr. Frank A. Herrmann, Chairman of the CTH and Director of the WES Hydraulics Laboratory, also welcomed the CTH and guests. He said that the CTH last met at WES in 1987, a budget-induced departure from past practice of meeting twice a year—once at WES and once at a district or division.

### WES Model Studies

7. Galveston Bay. Dr. R. Charlie Berger of WES presented the Galveston Bay salinity modeling study. Galveston Bay, approximately 25 miles long by 20 miles wide, has typical water depths of 6 to 8 ft below the National Geodetic Vertical Datum (NGVD). The navigation channels from Bolivar Roads to the Port of Houston are 40 ft deep by 400 ft wide. USACE and the local sponsor, the Port of Houston, propose enlarging the channels in two phases to 45 by 530 and 50 by 600 ft, respectively. Dredged material will be used to construct islands in the bay.

8. The U.S. Army Engineer District, Galveston, has asked WES to investigate ship safety issues and circulation/salinity intrusion changes arising from the proposed channel enlargement. The circulation/salinity intrusion predictions will be used in an oyster model developed by Dr. Eric Powell at Texas A&M University to evaluate the fisheries impacts of the channel enlargement.

9. WES is using a three-dimensional (3-D) numerical model to predict changes in circulation and salinity. The model, employing the RMA10-WES code, reproduces the Gulf of Mexico in two dimensions (2-D) and most of the bay system in 3-D. The finite element solution model (a WES modification of Dr. Ian King's model) was selected because of the need to reproduce a deep channel in a shallow bay with wetting/drying possible and the capability of adding perhaps two dozen islands as the study progresses.

10. The model has been verified to 9 months of 1990 field observations of tides, velocities, and salinities, and has shown good agreement with the field data and with observations of those who work in the bay. The field data period included the flood of record followed by a normal low riverflow.

11. For testing purposes, the model reproduces all the major freshwater inflows, two power plant cooling flows with widely separated intakes and outfalls, synthesized tides for a year, and winds measured in 1990. Freshwater inflows are divided into typical low and high flows and a mean flow for the present condition plus three future conditions—1999, 2024, and 2049. The future freshwater flows are based on interbasin diversions to satisfy the Houston area demand for water.

12. Dr. Berger described model sensitivity testing that has shown a 2-ppt change in Gulf salinity causes a 0.5- to 1.8-ppt change in bay salinities, with the higher values in the inlet and lower values in the upper bays. (The 2-ppt variation is representative of Mississippi River plume-caused variability observed in Gulf salinity over a 15-year period of record.) A 10 percent variation in freshwater flows induced a change of 0.2 to 1.2 ppt.

13. The model testing of first phase enlargement is complete, and Dr. Berger showed slides and an animated video to illustrate the results. As expected, the channel enlargement caused the salinity contours to move landward, sometimes in unforeseen ways. As an example, the cooling water intake of one power plant was seen to transfer higher salinity water from near the channel to a much fresher environment, skewing the isohalines in that area. Changes of up to 2 ppt in monthly average salinity were seen in some locations.

14. The model testing has now produced more than a decade of simulation time, and more than 100 gigabytes of data. Only through animation and the oyster modeling can effective use be made of so much information.

15. Questions posed by the CTH and answers were as follows:

- a. Mr. Henry B. Simmons, consultant: Is Rollover Pass still open? Answer by Mr. Edward A. Reindl, Jr., Galveston District: It is still open and still controversial. It is stable now, thanks to a sheet pile weir.
- b. Ms. Virginia R. Pankow, Water Resources Support Center: Where are the oysters? Answer by Mr. Reindl: They are everywhere in the bay.
- c. Dr. Donald W. Pritchard, consultant: Are oyster predators are being modeled? Answer by Dr. Berger: Both viruses and predators are being modeled by Texas A&M.
- d. Mr. John G. Oliver, North Pacific Division: What channel side slopes were modeled? Answer by Dr. Berger: The existing 1V on 7H slopes were used in both base and plan tests.
- e. Drs. Pritchard and Ray B. Krone, consultant: How does the numerical model treat diffusion? Answer by Dr. Berger: Horizontal diffusion was computed by eddy viscosity in a streamwise fashion, and vertical diffusion was computed by Mellor-Yamada Level II scheme with Henderson-Sellers damping by stratification. A small background diffusion is used, but is not necessary for numerical stability.

**16. San Francisco Bay Long-Term Management Strategy for Dredged Material.**

Mr. Thad C. Pratt of WES described the WES field and model study in support of the San Francisco District's Long-Term Management Strategy (LTMS) study. The LTMS is a comprehensive study, with many nonmodeling components, developed and guided by interagency work groups. The objectives of the WES Hydraulics Laboratory effort are to (a) provide tools for predicting the probable fate of dredged material disposed in open water, (b) refine the sediment budget for the bay, (c) provide guidance for use of the models to manage dredged material disposal, and (d) provide a framework for further development to achieve a fully 3-D numerical model of sediment transport in San Francisco Bay. The work is constrained by a budget of about \$600,000 and a requirement to be completed in 18 months.

17. The WES approach was to conduct a small supplemental field data collection program for 2 weeks in June 1992 and use those data to complete development of several numerical models. Since a full 3-D sediment transport model could not be developed and verified within the constraints, a combined 2-D—3-D approach was designed. A 3-D hydrodynamic and conservative transport model is being used to predict how a nondepositing cloud of sediment will disperse from the disposal sites, and a 2-D sediment transport model is showing how sediment will move, deposit, resuspend, and move again without density-induced circulation. Residual currents will be computed from the 3-D and 2-D hydrodynamic model results by integrating the computed currents over multiple tidal cycles. The several results will be compared to generate a probable distribution of sediment.

18. The 1992 supplemental field data program (hydrodynamic data were previously collected by several agencies, and sediment flux data were collected by WES in 1988) measured tides at six locations in the bay and currents, salinity, and suspended sediments at six ranges. Two ranges were monitored by moored recording meters and samplers, while ranges at Golden Gate, South Bay Entrance, lower San Pablo Bay, and Raccoon Straits were monitored by boats equipped with Acoustic Doppler Current Profiling (ADCP) meters. Twenty-five water samples were taken at each cross section each hour. The boat-based data collection was conducted for 12 hours per day for 2 weeks.

19. The ADCP meters were used in cross-section profiling mode, so profiles over both width and depth were produced. Three of the ADCP meter ranges were monitored with 1,200-kHz instruments that provide 1-m resolution. The Golden Gate range ADCP meter was a 150-kHz instrument that has greater range but only 2-m resolution. The backscatter intensity was calibrated with a Dredging Research Program-developed equation to yield continuous profiles of sediment concentration and flux.

20. A Landsat thematic mapper image was obtained for the 1992 survey period, and it is being used to complement the measured sediment transport patterns with spatial detail of surface sediment concentrations.

21. Five potential disposal sites will be tested for a spring-neap tidal sequence with mean fresh-water inflow and winds. The following questions are to be answered:

- a. By how much will suspended sediment concentrations be raised over background levels?
- b. Where is the disposed sediment located 2 weeks after disposal?
- c. What is the probable long-term fate of the disposed material?
- d. Will disposed sediment deposit in or pass through certain sensitive sites?
- e. What are the critical values for dredged sediment disposal rate and erosion characteristics for a given site to be dispersive or retentive?

22. Products of the effort will include documented, verified, time-varying numerical models of 2-D sediment transport and 3-D hydrodynamics and salinity transport that can be used to manage open-water dredged material disposal and extended to produce a fully 3-D sediment transport model.

23. The following questions were posed by the CTH and answered:

- a. Mr. Oliver: (1) What Corps projects are involved in disposal in San Francisco? Answer: John F. Baldwin Phase III (JFBIII) channel new work, Oakland Harbor new work, and maintenance dredging.
- (2) Will the resource agencies accept the results? Answer: We believe so. They were involved in writing the scope of work and physically signed off on it.
- (3) How will confidence limits be set on the results? Answer: The usual technique of making multiple runs with varied input specifications is not permitted by the schedule. The 2-D—3-D comparisons will be used, and Allen M. Teeter of WES is attempting to develop an additional approach.
- b. Mr. Reindl: (1) Can the model predict channel maintenance dredging requirements? Answer: Yes.
- (2) Does the model include river sediment loads? Answer: Yes.
- c. Drs. Krone and Pritchard: The residual current comparison will not include the effect of deposition during slack water. How will that be captured? Answer: We agree. The 2-D sediment modeling will capture deposition and resuspension, but not the vertical circulation. That's the compromise we had to make to fit into the available time and budget.
- d. Mr. Herrmann: (1) Do you have a feel for how big a role vertical circulation plays? Answer: In Central Bay, where the disposal sites are, the vertical, gravitational circulation is very small compared to the tidal pumping. The same is true in South Bay. Gravitational circulation is stronger in San Pablo Bay and Carquinez Strait, and the 2-D model is weakest there.
- (2) How much of the mesh is 3-D and how much is 2-D? Answer: The break point is 6 ft deep. Shallower water is 2-D; deeper water is 3-D.
- e. Mr. Simmons: Have you compared 3-D model results with the San Francisco Bay-Delta physical model? Answer: Yes. They compare very well as shown by our JFBIII work.
- f. Dr. Ming Tseng, Headquarters, U.S. Army Corps of Engineers (HQUSACE): I am very concerned about the 2-D results between Alcatraz site and Golden Gate. When can we see results? Answer: In about a month.
- (2) Isn't the U.S. Geological Survey (USGS) studying the bay? Answer: Yes, and we are coordinating with them. The LTMS is presently funding USGS sediment studies to complement our work.
- g. Dr. Pritchard: Are you using other agency data, such as that collected by USGS? Answer: Yes. Also National Ocean Service data collected several years ago.
- h. Mr. Samuel B. Powell, Liaison, HQUSACE: Is biological modeling being done? Answer by Dr. Krone: Yes, at University of California at Davis. Mr. Herrmann: The entire LTMS is costing \$10 million. This modeling is just a small part.

- i. Dr. Krone: This work is critical to the future of the bay. The dredging situation is crippling the area's economy, with \$100 million per year at the Port of Oakland alone. According to Tom Wakeman (LTMS Manager), the existing disposal sites have a capacity that is a million cubic yards per year less than the need. The resource agencies fear contaminated sediments, and the fisheries are dying, but reasons are unknown. We must have knowledge of sediment fates. We also need quantification of freshwater effects.

24. **C&D Canal Study.** Dr. Billy H. Johnson, WES, presented two related model studies of Delaware Bay and the Chesapeake and Delaware (C&D) Canal. Both are using the 3-D numerical model CH3D-WES, which was developed by WES under the Chesapeake Bay study.<sup>1</sup> CH3D-WES, based on an earlier model by Peter Sheng, uses a finite difference solution on boundary-fitted coordinates using contravariant variables and a z-plane vertical mesh. The turbulence closure is algebraic.

25. The C&D Canal study has the immediate objective to determine net transport through the canal, which has been the topic of a number of previous efforts. The computational mesh has 6,200 cells with a maximum 16 and minimum 2 vertical layers. Using a 2-min time-step, the model takes about 4 hours of CRAY Y-MP time to run 3 months of prototype time. Downstream boundary conditions are specified at the Chesapeake Bay Bridge and the mouth of Delaware Bay. The model thus includes all of both Chesapeake and Delaware Bays. Wind specifications for upper Chesapeake Bay are derived from Baltimore Airport data; for Delaware Bay, from Wilmington, Delaware; and for the canal, interpolated between the two stations.

26. The initial verification was to a low riverflow 1984 data set. Because no salinity data are available for the Delaware mouth boundary, that boundary condition was developed by trial. Sensitivity testing showed that the tide data at the mouth had a datum error that had to be corrected for verification. The verification was good. The next verification phase used high riverflow conditions from 1984, and again the verification was good.

27. Various scenarios are now being run to determine net flow through the canal using 1984 conditions and a range of riverflows ranging from the historical low to high and channel depths of 35, 40, and 45 ft below NGVD. For September 1984 the net flow was to the west.

28. Questions posed by the CTH and Dr. Johnson's answers were as follows:

- a. Mr. Powell: Dean O'Brien found that interpolating wind data from three stations was inadequate for the Columbia River estuary, because they were uncorrelated. Are the wind data from Baltimore and Wilmington sufficient? Answer: It is a problem, but we have found that the data work if we adjust the wind stress coefficient in Hsu's equation.
- b. Dr. Pritchard: Dave Goodrich's thesis used National Oceanic and Atmospheric Administration (NOAA) buoy wind data and compared it with Patuxent Naval Air Station data. Did you use that? Answer: We used it in the Chesapeake Bay work.

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<sup>1</sup> B. H. Johnson, R. E. Heath, B. B. Hsieh, K. W. Kim, H. L. Butler. (1991). "Development and verification of a three-dimensional numerical hydrodynamic, salinity, and temperature model of Chesapeake Bay; Volume I: Main text and Appendix D," Technical Report HL-91-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.



29. **Delaware Bay Channel Deepening.** Dr. Johnson explained that the Delaware Bay study objective is to predict salinity intrusion and circulation changes arising from deepening the navigation channel to 45 ft (from its present 40 ft) below NGVD from Miah Maul Light upstream to Philadelphia Harbor and Camden Harbor. The deepening will begin about 6 miles upstream of the bay mouth.

30. In support of the model study, a yearlong field investigation began in October 1992. Tides, velocities, and salinities were recorded by fixed instruments at 12 locations in the bay for the entire year, although instrument theft interrupted some of the records until the instruments could be replaced. Two-week intensive data collection efforts twice during the year provided velocity and salinity profiles—three to five depths at two to four stations at each of seven ranges.

31. The numerical model base mesh contains 10,535 cells, with 1,992 surface cells and a vertical cell depth of 5 ft. The ocean boundary lies at the mouth of Delaware Bay. A second test mesh extends the ocean boundary about 40 nautical miles farther into the Atlantic Ocean and adds about 6,000 cells to the mesh.

32. Dr. Johnson described sensitivity tests to determine the optimum time-step length and appropriate location of the ocean boundary. The base and enlarged ocean meshes produced virtually identical tides and velocities at the bay mouth, but a 0.05-ppt salinity difference.

33. Time-steps of 1, 2, 4, and 6 min were tested on the base mesh. Very little difference can be seen between 1-min and 2-min results. A 4-min time-step produces results that vary from 2-min results by the amounts shown in the following tabulation:

Parameter	In Lower Bay	At C&D Canal
Tide, cm	1	0.05
Velocity, cm/sec	2	8
Salinity, ppt	0.4	1 (at the 7-ppt isohaline)

The 6-min time-step made the model unstable.

34. Dr. Johnson asked the CTH to comment on the appropriate boundary location and the proper time-step. He believes the 2-min time-step most appropriate, but would like to use 4 min if possible. Will base-to-plan comparisons cancel out the differences? Using the larger mesh and 2-min time-steps will exact a computational penalty, but can be accomplished.

35. Dr. Pritchard asked what kind of recording meters are being used. Answer: ENDECO Models 1152CTD and 174SSM and Hydrolab salinity probe model H20.

36. **New York Bight.** Mr. H. Lee Butler of WES presented the New York Bight study, which has the objective of establishing the feasibility of modeling, monitoring, and establishing a database to assess impacts of management activities on the bight. In 4 years of investigation and workshops, major products include a hydrodynamic model (CH3D-WES), a water quality model, and a database.

37. The hydrodynamic modeling goals are to simulate the flow field and temperature and salinity distribution of the bight in order to supply these results to the water quality model. The model reproduces the areas from Cape May north to Nantucket Shoals and offshore to the shelf break. It includes lower New York Harbor and Long Island Sound. The mesh contains about 3,000 horizontal cells and 10 layers in the vertical. Unlike the previous CH3D-WES applications described, the bight model employs sigma stretching in the vertical.

38. Testing thus far has consisted of qualitative evaluations of steady-state responses to wind and freshwater flow and quantitative testing of a pure M2 tide, mixed tides, and variable boundary conditions. Verification data are from April and May 1976. Tide and velocity results match well with measured data. While the model does a good job in reproducing tidal events, it is limited by the lack of measurements at the ocean. Results in complex geometry areas are limited by model resolution.

39. Environmental issues include consideration of dissolved oxygen, contaminants, floatables, and general eutrophication parameters. The environmental models include these items plus an oil spill tracking capability.

40. The water quality model, developed under the Chesapeake Bay project, tracks 11 state variables in a 3-D finite volume computation. Its verification to transect data from ship cruises is pretty good, but large variations in the field observations make comparison difficult. It duplicated the 1976 hypoxia region along the New Jersey coast fairly well. Testing has shown the bight to be insensitive to upland nutrient loads and to ocean boundary conditions, but the transect region is sensitive to both.

41. The contaminant screening model, RECOVERY, is personal computer (PC)-based and uses a zero-dimensional calculation. It is designed as a screening level model for site-specific application.

42. The particle tracking model was developed for floatable debris and reproduced observed drogue paths very well, which implies that the hydrodynamic model-generated currents are good. Floatables are a less important issue now that sea burning of debris has cleared. However, the model is fully 3-D and can be used, for example, in tracking particles being released from an underwater disposal mound.

43. Applied Science Associates developed the PC oil spill model WOSM with funding by a consortium of private and public organizations, including WES. This model couples a Geographic Information System (GIS) with sophisticated surface transport algorithms and a worldwide meteorological-ocean database to predict the fate of surface pollutants. Coupled with bight hydrodynamics it provides the Districts a capability for spill contingency planning.

44. The Bight Biological Review Program has the objective of identifying data and models needed to examine marine resource impacts. It consists of four tasks:

- a. List and prioritize major impacts likely from each hypothetical project.
- b. Identify which impacts can be adequately examined with existing data and models.
- c. Prioritize information gaps and outline how to fill them.
- d. Identify types of mitigation appropriate for large-scale projects.

45. A GIS (using Intergraph hardware and software) was developed for integrating numerical results from each model and various measured data (for example, ship observations, gage data, bathymetry, satellite imagery, etc.) in a geo-referenced framework, useful for analysis and decision-making processes.

46. Questions by the CTH and answers were as follows:

- a. Dr. Pritchard: (1) What wind field data are used? East River discharge is very dependent on wind direction and magnitude. Answer: Measurements from several land stations have been corrected for land-sea differences and blended with buoy data and over-water winds from the National Weather Service.
- (2) Are NOAA's ADCP data in Long Island Sound being used? Answer: Yes, these data were extremely useful in validating the East River connection between the harbor and sound.
- c. Mr. Powell: Who does what in case of an oil spill in the bight? Answer: The Coast Guard (response) and NOAA (technical advisor) have the mission. USACE has questions of its own to address. The Corps is often called for assistance; hence the New York District has a strong interest in a contingency planning model.
- d. Dr. Krone: Does the Gulf Stream shed eddies in the bight? Answer: Yes. There is a need to measure eddy influence on the bight shelf.

46. Coast of Delaware Study. Mr. David J. Mark of WES explained that the Philadelphia District is conducting a storm damage reduction study for the coast of Delaware. To construct a set of stage-frequency curves, a hydrodynamic model is being run using synthetic weather data. The components are (a) a wind and pressure field model, (b) a hydrodynamic model, and (c) an empirical simulation technique.

47. The wind and pressure model employs V. Cardone's planetary boundary layer model, a 2-D, vertically averaged computation of atmospheric moisture, heat, and momentum flux. Five nested subgrids are in use, each 21 by 21 cells with the center at the eye of the hurricane. Cell sizes are 5, 10, 20, 40, and 80 km, and computations proceed from the coarsest to the finest grid. Input data include the location of the storm eye with time, forward speed, and pressure deficit, which are obtained from the National Hurricane Center's database, and radius to maximum wind, which is estimated.

48. Westerink's hydrodynamic model, ADCIRC, computes the water level and flow field. It solves the 2-D, depth-integrated generalized wave equation using a finite element formulation on an unstructured grid. The grid in use covers all of the U.S. Atlantic coast and part of South America, plus the Gulf of Mexico. It has 21,917 elements with spatial resolution varying from 325 m to 193,000 m. It has been verified to eight tidal components for September 1985 for stations on the New Jersey, Delaware, and Maryland coasts. Comparisons with observed data are fairly good at Lewes, Maryland, where the model sometimes underpredicts water level. Skill tests (verification) used to quantify accuracy include the ratio of computed to observed maximum water level, average phase lag, and root mean square magnitude and lag. Hindcast of Hurricane Gloria (the storm of record) overestimates surge level by 0.2 ft with a 1-hour lag at Lewes.

49. Production modeling consists of running 15 parameterized storms using data from those that have originated within 200 miles of the Delaware coast, then using the empirical simulation technique to generate the stage-frequency curves.

#### **Dredging Research Program**

50. Mr. E. Clark McNair of WES provided an overview of the Dredging Research Program (DRP), which is a \$35 million, 7-year research effort designed to save money spent in dredging. The program will wrap up in 1994 with technology transfer in workshops, demonstrations, and reports. Its five technical areas and examples of research in each are as follows:

- a. Analysis of dredged material disposed in open water.
  - (1) Dredged material disposal models.
  - (2) ARMS (Acoustic Resuspension Measurement System): measurement of bed sediment entrainment potential and sediment transport by a bottom-resting device.
  - (3) PLUMES (Plume Measurement System): measurement of currents and suspended sediment concentration by a vessel-mounted ADCP.
- b. Material properties related to navigation and dredging.
  - (1) A towed sled that measures characteristics of fluid mud to establish navigable depth.
  - (2) Acoustic impedance techniques to rapidly determine approximate subbottom densities.
  - (3) An instrumented drill rig to log drilling parameters and produce information on rock dredgeability.
- c. Dredge plant equipment and system processes.
  - (1) Submersible pumps for small localized dredging needs. (Produces \$500,000 savings for each Red River lock approach application.)
  - (2) Water injection dredging that pumps high-volume, low-pressure water into the bed, causing slumping into adjacent low spots.
- d. Vessel position, survey controls, and dredge monitoring systems.
  - (1) Survey and dredge vessel positioning by Global Positioning Satellite (GPS) within 4 in. of actual location.
  - (2) Silent Inspector, which logs dredge operating parameters, such as location, production rate, etc., and sends it to a shore station for use in certifying payment to contractors.

e. Management of dredging projects: software and guidance on managing dredging projects.

51. Technology transfer, consisting of more than 5,000 items, is being accomplished through Tech Notes, video reports, workshops, Engineer Manuals, field demonstrations, technical reports, information bulletins, Executive Notes, and technical assistance responses.

52. Dr. Krone asked if reducing sedimentation was included as a research topic in the program. Mr. McNair replied that it was not.

53. Modeling short-term fate. Dr. Johnson presented the DRP work unit that is to provide models (STFATE) for predicting the short-term fate of dredged material that is disposed in open water. These models, developed originally by Koh and Chang for the Environmental Protection Agency and improved under the previous Dredged Material Research Program (DMRP), are being modified for PC use and to incorporate improved physical descriptions of the disposal processes. The STFATE models can be used to provide input to long-term fate models (they will be combined into a single model) and to address such environmental concerns as mixing zones.

54. The processes following disposal from a barge or hopper dredge can be grouped into convective descent, dynamic collapse, loss to the water column, bottom surge, and passive transport/diffusion. Major factors influencing these processes are the method of disposal, type material, and the receiving environment.

55. Large-scale laboratory tests at WES and field experiments were conducted to provide data for model improvement. The tests employed two scaled disposal vessels, a 1:50-scale split-hull barge and a six-bin hopper dredge, in a 50- by 40- by 8-ft-deep basin. Sands, fine crushed coal, silt, and buck-shot clay were dumped from the model vessels and the results recorded through video, water sampling, and measurement of deposit thickness (where possible).

56. Field data sets were collected from open-water disposal operations at Mobile Bay, Miami, and San Diego.

57. The laboratory and field data were used to improve the physics within the model, particularly stripping of sediment from the jet, the behavior of nonhomogeneous material, cohesive sediment settling, and damping turbulent diffusion. The dynamic collapse phase is now treated by conservation of total energy.

58. Questions posed by the CTH and Dr. Johnson's answers were as follows:

a. Mr. A. David Schuldt, Seattle District: Do we know what effect the disposal has on the bottom biota? Answer: No.

b. Dr. Krone: How is energy dispersion calculated? Answer: It is based on Bokuniewicz and Gordon's work, which uses energy sink terms for various processes.

59. Long-term fate of disposed sediments. Dr. Norman W. Scheffner, WES, presented the companion work to the short-term fate model development. The long-term fate (months to years) model considers disposed dredged material movement from the mound formation on. Its objective is

to develop a systematic approach to answering the questions: Does the sediment move? Where does it go?

60. The numerical model LTFATE is a coupled hydrodynamic and sediment transport computation for a mound of arbitrary bathymetry. It considers the effects of currents (tidal and storm surge) and waves. The model ADCIRC, described in the presentation on the coast of Delaware study, supplies local hydrodynamic boundary conditions to the LTFATE model, and a stochastic wave simulation model supplies time-histories of wave height, period, and direction using the 20-year Wave Information Study database.

61. The hydrodynamic boundary conditions and wave conditions are used by LTFATE to compute sediment movement in a box model approach (sediment in minus sediment out equals deposition).

62. The model has been applied to several sites, including the New York Mud Dump, which showed that the site is reasonably nondispersive.

63. Comments and questions and Dr. Scheffner's answers were as follows:

- a. Dr. Krone: What sediment transport function is used? Answer: Ackers-White and Bijker for sands. Mr Teeter supplied the cohesive sediments equations.
- b. Mr. A. Jay Combe, New Orleans District: Does the hydrodynamic model handle wetting and drying? Answer: No. We plan to add that capability under the Inlets Research Program.
- c. Mr. Butler said that the ADCIRC model has become the standard USACE hurricane surge model.

64. Defining dredging needs in fluid mud. Mr. Teeter explained that the objective of this DRP work unit is to develop improved methods for defining dredging requirements in fluid mud-prone areas. The Netherlands developed the navigable depth concept based on fluid mud density, which they measure using an intrusive nuclear gage, which is an accurate, but rather slow method. They knew, as USACE does, that acoustic fathometers, even multiple-frequency devices, give ambiguous measurements of the actual density of fluid mud; and readings are dependent upon tuning the fathometer to the in situ mud structure. Mr. Teeter believes that the navigable depth concept must also reflect mud viscosity.

65. A towed device was tested in an attempt to overcome the limitations of existing density measurement methods. The initial design (Enclosure 1) uses ultradense polyethylene catamaran hulls to support an instrument sled containing a 3-millicurie cesium radiation source in a transmission gage, velocity meter, tilt sensors, two accelerometers, and a tracking beacon (in case the sled becomes detached from its cable). The sled is towed by an armored steel cable equipped with a strain gage and tilt sensor. The towing vessel is equipped with an IBM-PC controlled helm indicator, mini-ranger positioning system, Odum Ecotrac fathometer, and a 5-hp winch. Data logging is controlled by an HP 9000 computer. The sled is towed 60-70 ft behind the vessel.

66. Two modes of sled operation have been successfully tested: a profiling mode in which it dives below and then rises above the target density, and a planing mode in which it rides at a preset

density and viscosity. The sled is accurate in either mode, but the safety requirements of the cesium source make it somewhat expensive to maintain. The latter towing mode is preferred as it allows for the most rapid and complete survey of navigable depth.

67. A second, simpler device has been designed and built to complement the sled. It is a 33-in.-long, 6-in.-diameter cylinder/cone with built-in tilt and pressure sensors. It is towed like the sled at a preset density and viscosity, but a smaller vessel is possible. It seeks a depth at which the mud density and viscosity balance its submerged weight.

68. Field tests in Calcasieu Channel in Louisiana were used to define operation characteristics and accuracy of the sled. The site has a 1.7-ft tide range and 3- to 4-fps currents in the 42-ft-deep by 800-ft-wide navigation channel that traverses a shallow offshore area. A fluid mud layer up to 13 ft thick (14 million cubic yards per year) accumulates in the channel. One 6,000-ft-long range was selected for repeated surveys by standard dual-frequency acoustic fathometer and the towed sled. For pre- and post-dredge surveys, the 24-kHz fathometer record showed no change in depth, the 200-kHz record showed an incorrect depth change, and the sled result agreed with a standard vertical-drop nuclear gage. The simple towed device produced results equivalent to the sled (Enclosures 2 and 3).

69. Mud samples were collected using a WES-designed sampler that employs ball valves to pull four samples simultaneously at a chosen vertical spacing. More than 50 samples were taken at Calcasieu and then tested in the WES controlled stress device (two concentric cylinders). The results show that the optimum density criterion for navigable depth is site specific, but the sled results are consistent from site to site.

70. Mr. Schuldt asked if the Calcasieu dredging removed mud or water. Mr. Teeter replied that the draghead was set to project depth and then fluid mud was removed by pumping.

70a. Mr. Powell recalled that the viscosity of fluid mud is sensitive to water temperature (stiffer in colder water). Mr. Teeter agreed it is quite sensitive and stated that the sled responds to temperature change.

## **Environmental Effects of Dredging Programs**

71. Mr. Thomas R. Patin of WES presented the Environmental Effects of Dredging Programs, which is a management device for a collection of related programs. It encompasses Dredging Operations Technology Support (DOTS), Long-Term Environmental Effects of Dredging Operations (LEDO), The Center for Contaminated Sediments, and related mission support work.

72. DOTS. DOTS, funded by Operations and Maintenance, performs mainly technical support to the USACE Districts and Divisions. DOTS responses may cover 7 to 10 days of senior scientist/engineer time plus travel costs at no charge to the requester. It includes legislative review and testimony, interagency liaison, litigation support, toxicology consulting, document review, international activities, and assistance with model applications or plan formulation. Since 1978, 2,600 requests for assistance have been made. Also funded by DOTS are short (2-year maximum) studies of dredged material management that go between research and application, for example, making a computer model easier to run, and guidance on confined disposal site maintenance. DOTS also includes training and technology transfer.

73. **LEDO.** The LEDO program conducts research to predict and minimize long-term adverse environmental effects of dredging, particularly those related to contaminated sediments. It addresses aquatic, wetland, and terrestrial sites, chronic sublethal effects of contaminated materials, and volatile contaminant loss from land sites, among others. Applications of LEDO techniques are illustrated by the long-term evaluation of disposal sites at Black Rock Harbor, Long Island, and Times Beach, New York.

### **Protection of Sea Turtles from Dredging**

74. Dr. Lyndell Z. Hales, WES, explained that the sea turtle protection research is funded by the South Atlantic Division's Districts, with additional funding by the U.S. Navy. The program is being carried out with the cooperation of the National Marine Fisheries Services. Its purpose is to reduce or eliminate harm to endangered sea turtles from hopper dredges. The multilaboratory project's first action was to set a dredging window of December to March in consultation with National Marine Fisheries Service in order to protect the turtles while research was begun. The research has three major components—finding the turtles, getting them out of the dredge path, and preventing their ingestion by the dredge. Biological studies have attempted to determine the relative abundance of turtles and their behavior, and to verify that the December-to-March window is valid. Engineering studies have examined acoustic dispersal of turtles by an air gun and a dredge draghead deflector to push turtles out of the way. Field tests have shown that acoustic dispersal works, provided there is a 10-day interval between uses, since the turtles become acclimated to the air gun; and that the deflector draghead works in pushing full-scale model turtles out of the draghead path. The draghead also is slightly more efficient in dredging than a standard draghead. On the other hand, acoustic detection of the turtles was not successful.

75. Dr. Hales concluded with a videotape displaying some of the field tests. He said that USACE is committed to the safest possible environment for sea turtles.

76. Questions posed by the CTH and answers were as follows:

- a. Mr. Powell: Do the turtles congregate in navigation channels? Answer: That is still being investigated, but there seems to be a temperature dependence in the turtles' choice of resting areas.
- b. Ms. Pankow: What is the zone of influence of the draghead? Answer: Turtles at least 1 ft away from the draghead edge are safe if the draghead is firmly on the bottom.
- c. Mr. Simmons: What about an articulated deflector that maintains firm contact with the bed? Answer: Initial designs show promise, but mechanical problems have occurred. The Marine Design Center is working on the idea.

### **Wetlands Research Program**

77. **Program overview.** Mr. Glenn Rhett, WES, Assistant Program Manager of the Wetlands Research Program (WRP), presented the WRP Overview. WES has been engaged in wetlands research for more than 20 years. Huge losses in wetlands have occurred in the United States, with



50 percent of the 1,780 U.S. wetlands now gone. Recent interest in identifying wetlands and their boundaries and restoring and managing wetlands has increased the funding for wetlands studies by the Corps.

78. The WRP is a 4-year, \$22 million applied Research and Development (R&D) effort with a strong field demonstration emphasis. Forty-three demonstration sites have been selected, of which 17 are in tidal areas. (See Enclosure 4 for a list of tidal demonstration sites.) Its research is being accomplished in the following six technical areas with specific work units noted:

- a. Interagency Coordination**
- b. Technology Transfer**
- c. Delineation and Evaluation**
  - (1) Identification and delineation of jurisdictional wetland boundaries
  - (2) Evaluation of the functions and values of wetlands
- d. Restoration, Protection and Creation**
  - (1) Improved Wetlands Design criteria
  - (2) Techniques, structures, and equipment for wetlands restoration and creation
  - (3) Wetland field demonstrations
- e. Stewardship and Management**
  - (1) Technology for managing wetlands
  - (2) Cumulative impacts analysis
  - (3) Techniques for characterizing changes to wetland systems
  - (4) Automated analysis, display, and information bases for wetland systems
  - (5) Wetland stewardship and management demonstration areas
- f. Critical Processes**
  - (1) Hydraulics and hydrology processes
  - (2) Water quality processes
  - (3) Soils and vegetation processes
  - (4) Sedimentation processes

79. The Wetlands Research and Technology Center manages the WRP along with reimbursable studies and the Wetlands Regulatory Assistance Program. It conducted 20 training courses last year, mainly for Federal and State agencies.

80. Questions and answers were as follows:

- a. Mr. Herrmann: What is the status of the new Wetlands Delineation Manual?
- b. Answer: The Corps 1987 Delineation Manual is now serving as the official manual for the identification and delineation of jurisdictional wetlands under Section 404 of the Clean Water Act. The National Academy of Sciences is currently reviewing the 1987, 1989, and 1991 revisions to the 1989 delineation manual and will recommend revisions to update this document.
- c. Mr. Herrmann: Will there be a follow-on wetlands research program?
- d. Answer: Yes, A General Investigations program has been proposed. It will likely have less funding per year than the present program but, it is hoped, will be of longer duration. It is intended to field verify the techniques and methods developed under the WRP and to expand into new wetlands types, such as depressional and riparian wetland types.
- e. Mr. James Hubbard, National Ocean Service: Does the WRP partner with Coastal America?
- f. Answer: Not directly, but there are contacts between WRP researchers and those involved in this program.
- g. Mr. Powell: Is there a value hierarchy for wetlands?
- h. Answer: There is an effort to implement a wetlands categorization system, but it does not establish a high, medium, or low value. Some states have instituted such an approach, and the current and past Presidential Administrations have been investigating the feasibility of implementing such a plan nationwide.
- i. Mr. Powell: How deep must the water be to classify a site as aquatic rather than wetland?
- j. Answer: The agreed-upon depth is 2 m. This is based primarily on light penetration through the water column.
- k. Mr. Powell: What has been accomplished under the Breaux Bill to demonstrate wetlands creation in Louisiana?
- l. Answer: It is my understanding that the wetlands research program established by the Breaux Bill has focused primarily on small-scale field tests rather than large-scale field demonstrations. The larger projects are more than likely scheduled for the near future.
- m. Mr. Oliver: How far along is work on wetlands water quality analysis?

- n. Answer: A WRP effort is underway to provide a PC-based, screening-level technique to estimate the effects of wetlands on water quality. This technique will be used to assess and interpret the functional ability of wetlands to enhance water quality.
- o. Mr. Reindl: How are WRP and DMRP products brought together in such topics as beneficial use of dredged material to create wetlands?
- p. Answer: The WRP has built on the DMRP R&D mainly through the efforts of the researchers who have been involved in both efforts. Several WRP demonstration sites are located at old DMRP confined disposal areas where past monitoring results are being incorporated into long-term WRP monitoring efforts.

81. **Hydraulics of Louisiana wetlands sites.** Mr. Joseph V. Letter of WES presented WRP work that is evaluating methods of wetland creation and restoration in Louisiana. Louisiana wetlands are converting to open water, primarily because of a sediment supply that is inadequate to offset subsidence. Many attempts are underway to reverse that trend, and this work unit will document the techniques that work and demonstrate tools for evaluation.

82. Project sites have been selected for study based on hydraulic environment (current velocities, wave energy, sediment supply, and sediment supply potential) and methods used in creation/restoration. Projects are Tiger Pass, Mississippi River Delta splay cuts, Naomi-LaRuesette siphon, and Fina la Terre banking site. The entire region is being digitized into a hydrography database, which is then used with numerical hydrodynamic, transport, and meteorologic models to construct a first-generation numerical model of the processes of importance to marsh preservation.

83. The Tiger Pass project is a test of dredged material placement to construct a marsh. Three site types are used—four sites in open water, one diked placement, and one site confined by hay bales. Preliminary monitoring results showed that the hay bales permitted sediment to leak away, and the open-water sites did not retain sediment at all.

84. The Mississippi River delta splay cuts are an attempt to reproduce the natural distribution of sediments into delta lobes. In the Cubits Gap subdelta, 6-ft-deep by 100-ft-wide cuts at a 60-degree angle have been made through natural levees in San Raphael Pass by the State of Louisiana. Preliminary results show that the cuts do develop sand lobes, but they tend to close rather than enlarge.

85. The Naomi Siphon discharges up to 3,500 cfs from the Mississippi River into upper Barataria Bay. Constructed ridges and weirs direct the water and sediment along desired paths to areas that have converted to open water by subsidence.

86. The Fina la Terre site is an enclosed area owned by an oil company that attempts to manage the site to preserve marsh. It is surrounded by earth dikes and water level is controlled by weirs. Because it is closed off from the surrounding area, sediment cannot be naturally introduced to offset subsidence, so it is gradually converting to open water. The approach will be changed.

87. A Triangulated Irregular Network (TIN) database of the Mississippi River delta has been developed to support modeling activities. Various process models are being developed (hydrodynamics, meteorology, sediment transport, and sediment retention). The hydrodynamic model has

been developed and is being run in a steady-state mode to generate basic hydrodynamic behavior. Eventually this model will include wind waves.

88. Questions and answers were as follows:

- a. Ms. Pankow: What causes the subsidence? Answer: Tectonic downwarping, consolidation of sediments, oil and gas extraction.
- b. Dr. Krone: What are the criteria for success in marsh restoration? Answer: Creation of subaerial land and vegetation.
- c. Mr. Simmons: What agencies decide wetlands priorities and the best use of water and sediment? Answer: USACE decides how to manage its projects, and the State decides theirs.
- d. Mr. Powell: What effect do the water and sediment diversions have on main stem shoaling? Does it cause more dredging? Answer: It has not been evaluated for the overall impact yet. Individual diversions have minor impact; the global model of the delta is intended to define the cumulative impact.

## **ESTEX Flume**

89. Dr. Gregory Nail of WES described the planned ESTEX Hyperflume, a large-scale facility for unsteady, nonuniform flow and transport experiments. It is designed to be flexible and multi-functional so that a number of research goals can be pursued. It has grown out of the salinity flume that the CTH had constructed in the 1950's.

90. The present design is a product of USACE deliberations and a workshop sponsored jointly by the University of California, Davis, WES, and the National Science Foundation and chaired by Dr. Krone. WES is calling it a hyperflume to denote its size—the main basin will be 500 ft long, 70 ft wide, and 4 to 10 ft deep—and its flexibility. The main basin can be configured as two flumes or three flumes of variable geometry plus a deep basin. Enclosure 5 illustrates the hyperflume design. The design also calls for a 500- by 15- by 6-ft towing tank, several water storage sumps, and a water-conditioning facility. The main basin consists of Flume 10, a 10-ft-wide, 4-ft-deep fixed flume; Flume 60, a 60-ft-wide, 4-ft-deep flume that can be subdivided into two variable-geometry flumes; and a 60- by 90- by 10-ft-deep basin. The facility would be equipped with tide generators, a Lixator (for manufacturing salt water), and viewing ports through the walls.

91. The present maximum design flow capacity is about 110 cfs. Enclosure 6 provides some flow characteristics of the three primary flumes for steady stratified and unstratified flow at various flow rates and depths.

92. Presently envisioned experiments for ESTEX include sediment transport studies, which require a deep mobile bed and long deposition lengths; turbulence measurements; flow past obstacles such as piers; dredging equipment design tests; channel meandering studies; and ship effects studies.

93. Questions and comments by the CTH follow:

- a. Mr. Powell: The flow tables presented suggest that the range of Froude numbers may not be high enough, particularly to create bed forms. He also noted that sediment does not move uniformly or constantly, so measurements must take that into account. If the flume were deeper (say 10-12 ft), it could be used for testing hydraulic structures.
- b. Mr. Herrmann: The flume needs a tilting section. As an alternative, perhaps add higher walls at upstream end to generate larger slopes and higher Froude numbers. It may be wise to place pipes for a 300-cfs capacity, even if the pumps of that size are not installed at first.
- c. Dr. Krone: This flume will provide a facility for many fundamental studies that cannot be performed at present. For example, defining friction factors of muds requires a very long flume to measure the small differences in water level. The same is true for defining friction factors over sands for very shallow depths. ESTEX can be used to show the effect of water depth on Manning's roughness coefficient and to study vertical mixing in variable density flows. It is important to prepare a research program to begin the flume's work. (Dr. Krone also provided a follow-up letter with recommendations (enclosure 7).)

### **Monitoring Completed Coastal Projects**

94. Mr. William C. Seabergh of WES described the Monitoring Completed Coastal Projects (MCCP) project for Barnegat Inlet. The MCCP's objective is to learn lessons from completed projects in order to benefit them and future projects. The evaluations consist of data collection, analysis, and recommendations for revisions to design or maintenance.

95. Barnegat Inlet has been the subject of previous CTH consideration (26th and 63rd meetings). It is located 50 miles south of Sandy Hook, New Jersey, in the Philadelphia District. It is stabilized by arrowhead jetties, 3,000 ft long on the south and 5,000 ft long on the north, with their crests originally at mean tide level. The original navigation channel passed straight through the inlet, but secondary channels meandered between the jetties.

96. In the late 1960's maintenance dredging increases and undermining of the north jetty led to a WES physical model study. Subsequent construction raised most of the north jetty to +8 ft mean low water. As predicted by the model, the channel assumed an S-shape against the north jetty and the offshore bar began to grow. In 1988 work began on a new, parallel south jetty with a 1,000-ft-wide spacing.

97. The MCCP monitoring of Barnegat Inlet consists of annual hydrographic surveys and ADCP current profiles plus tide monitoring, wave measurements, dye studies, and side scan sonar imaging of the structures. Specific objectives of the monitoring are to determine if the channel and the south jetty are stable, if the new system has an impact on bay tides, if navigation safety has been improved, and if the physical model results were adequate. Mr. Seabergh asked for Committee suggestions on additional monitoring that should be performed.

## **Current Deflector Wall**

98. Mr. Michael P. Alexander, WES, presented the concept of the current deflector wall (CDW), a training structure developed at the Port of Hamburg, Germany, to control shoaling at channel junctions. A short study of the concept has been funded by the Repair, Evaluation, Maintenance, and Rehabilitation (REMR II) research program with the objectives of evaluating the CDW for U.S. use and identifying candidate sites for its application. Mr. Alexander asked the CTH to recommend potential sites if they knew of any suitable for such a structure.

99. The eddy that forms at branching channels pulls sediment into the circular flow near the bed, then traps it there so that a mound of sediment accumulates under the eddy. The CDW consists of a curved wall that captures some of the main channel flow and redirects it into the branch channel with a smooth transition. No large eddy is formed and sediment mounding is prevented. The design details and methods are patented by a European group that says it is willing to work with U.S. organizations who want to try the concept.

100. The prototype CDW was built in the Kohlfleet Harbor at Hamburg after model testing at the Franzius Institute. It cost the equivalent of \$1.65 million to construct, and the Port reports a 40 percent reduction in shoaling at the Kohlfleet, at a 2-year savings of \$8 million. (Hamburg sediments are contaminated and require special handling, so the cost per cubic yard is high.) Ship handling was also improved by the elimination of crosscurrents.

101. The WES examination has shown that the CDW concept has value, provided physical conditions of a site meet the criterion of shoaling under a channel branch-formed eddy. A report has been prepared giving site evaluation guidelines, but we need a good list of potential sites.

102. The following comments were made by the CTH:

- a. Mr. Powell: The concept reminds him of work done by the Meade Laboratory at the University of Nebraska. They ran tests of a second entrance for Missouri River Harbors. Tom Pokrefke of WES also tested ways of conveying sediment into a side channel. Either source might have good examples. Ask Warren Mellema of the Missouri River Division.
- b. Mr. Simmons: The Hydraulics Laboratory archives should contain model test results of ways to keep sediments out of Hudson River pier slips.
- c. Mr. Reindl: Model tests (physical and numerical) are needed before a demonstration CDW is built at a site.
- d. Potential sites mentioned by various members include Old River Diversion, Miami Harbor, Mayport Naval Basin, Brazos Channel (and all those that cross the Gulf Intracoastal Waterway), Brunswick Harbor, Wilmington Harbor on the Delaware River, and Ship Creek in Charleston Harbor.

## **Demonstrations**

103. The proposed computer-based tidal hydraulics bibliographic database was demonstrated by Mr. C. Steve Jones and Ms. Katherine M. Kennedy of the WES Information Technology Laboratory. Mr. William L. Boyt of the WES Hydraulics Laboratory demonstrated a GIS analysis and display of Landsat satellite imagery that delineated sediment plumes in San Francisco Bay and aided in model verification. Ms. Barbara P. Donnell, also of the WES Hydraulics Laboratory, provided a demonstration of a numerical modeling workstation, where preprocessing, model execution, and postprocessing are done under a graphical user interface.

## Executive Session

104. **New and old members.** Mr. Herrmann welcomed new member Ed Reindl and Sam Powell, who has been the temporary HQUSACE Liaison and has now been appointed to that position on a permanent basis. Certificates of appreciation for retiring members Glenn Drummond and Cecil Soileau were signed.

105. **Minutes of the 101st Meeting.** The minutes of the 101st meeting of the Committee were approved as submitted.

106. **Fiscal Report.** Mr. Herrmann submitted the Committee's final 1992 financial statement and an interim statement for Fiscal Year (FY) 1993. Both were approved. The budget for 1994 will probably be about the same as 1993.

107. Mr. Reindl asked if the budget could accommodate a recorder/stenographer to take notes so that the Executive Secretary could more fully participate in the meeting. Mr. William H. McAnally, Jr., Executive Secretary, WES, enthusiastically endorsed the suggestion. Messrs. Powell and Butler suggested that speakers before the Committee be asked to submit synopses (3 pages maximum) of their presentations and/or copies of their Vu-Graphs. After a brief discussion, both suggestions were adopted. A WES Hydraulics Laboratory stenographer will attend the meetings to take notes and the speakers will be asked to submit synopses.

### 108. WES Projects.

#### a. *Delaware Bay Salinity Modeling.*

- (1) In response to the first question posed by Dr. Johnson (Is the close ocean boundary sufficient for both base and plan testing?), Mr. Butler recommended additional sensitivity testing. He suggested that both base and plan navigation channels be tested for both ocean boundary locations and the change at the boundary be examined to resolve the question. It seems unlikely that the channel deepening will affect the boundary, but the possibility is enough to warrant testing it.
- (2) Dr. Pritchard agreed with that recommendation. He noted that the differences displayed in Dr. Johnson's plots showed phase shifts in the lower bay but offsets (biases) in the upper bay. The tide curve shapes suggested that overtides were changed by the time-step.
- (3) Mr. Simmons agreed and added that WES tested a 50-ft channel in the physical model of Delaware Bay, but did not publish the results. He recommended finding those data and comparing them with the numerical model results.
- (4) On the question of the time-step size, the Committee members agreed with Dr. Johnson that the 2-min time-step is appropriate. Mr. Butler suggested that the possibility of changing the relationship between internal and external mode time-steps might yield some computational efficiencies if needed.



- b. Barnegat Inlet.* Mr. Seabergh had asked if additional monitoring is recommended. Messrs. Simmons and Oliver said the existing monitoring is adequate.
- c. ESTEX.* Several comments were offered on the ESTEX flume design:

  - (1) Mr. Herrmann: The available discharge capacity in the 60-ft-wide portion may be too low, but additional capacity is very expensive and should not be installed unless it is definitely necessary.
  - (2) Mr. Powell: The design should include the relatively inexpensive pump pedestals and pipes for more flow capacity, perhaps the electrical connections also; then the pumps can be procured as experience dictates.
  - (3) Include a capability to permit easy access by equipment (Bobcats, etc.) with materials for construction and operations.
  - (4) Dr. Krone: ESTEX should be a national facility. Its uses will be broader than the CTH can presently plan for.

109. **Tidal Hydraulics Workshop.** Mr. McAnally explained that Dr. Nail has compiled a large volume of materials under the various workshop outlines previously reviewed and revised by the CTH. The material will next be converted into visual aids for the master workshop document.

110. **Tidal Hydraulics Bibliography.** The demonstration of the on-line bibliography was applauded. The CTH decided that if the copyright clearances for abstracts were obtained, the first year's effort will be funded at \$5,000, with a review at one year to decide the second year's funding. The Hydraulics Laboratory will provide a computer to run the bibliography. The 11th Supplement to the printed bibliography will be published, with a page announcing that it is the last printed version and will be replaced by an electronic database (going back to 1986).

111. Drs. Krone and Pritchard said that if the communications software needed to access the database (PCTOOLS COMMUTE) becomes unavailable, others such as PCLINK or HAS might work.

112. Mr. Butler said some known references were missing from the demonstration database. The Committee needs to be certain the keywords are appropriate and the right databases are searched.

113. Mr. McAnally was tasked to prepare a memorandum for the WES Information Technology Laboratory conveying the CTH's decisions.

114. **Cohesive Sediments Research Newsletter.** Mr. McAnally distributed copies of the latest edition of the Cohesive Sediments Research Newsletter (CSRN). It has 76 subscribers, 24 of them in the USACE and 22 outside the United States (12 countries, with multiple subscribers in Belgium, England, France, Denmark, Japan, and The Netherlands). Each semiannual edition costs about \$2,500 to produce. Collection of subscription funds costs more than it generates, plus WES has lost the capability to retain and use the subscription funds.

115. Mr. McAnally proposed that the CTH provide the \$5,000 per year to continue publishing and make subscription from outside the USACE contingent on submitting material for use in the newsletter. The CTH agreed the newsletter was a valuable undertaking, but noted that the budget could not support the entire amount. Mr. Powell noted that other newsletters are supported by R&D programs. He volunteered to seek formation of a tidal hydraulics R&D program that could fund technology transfer such as the CSRN, workshops, and monitoring completed estuarine projects.

116. Dependent upon FY 94 funds, a \$2,500 subsidy was approved. It was suggested that the Federal Interagency Sedimentation Project (FISP) might provide the other \$2,500.

117. **Indian River Inlet Report.** Mr. McAnally led a discussion of the remaining points of debate on the draft report analyzing the Indian River Inlet erosion problem from the 101st meeting of the committee. A final set of conclusions and Mr. McAnally promised to have a final draft out for review within 2 weeks.

118. **Election of Officers.** Mr. Powell chaired the election of CTH officers for FY 94. Mr. Butler nominated Mr. Herrmann for Chairman, Mr. Oliver seconded the nomination, and Mr. Herrmann was elected unanimously. Mr. Oliver nominated Mr. McAnally for Executive Secretary, Mr. Butler seconded it, and Mr. McAnally was elected unanimously.

119. **Next meeting.** The New Orleans District has indicated its intention to invite the CTH for a review of several projects. Mr. Powell suggested a theme of estuarine wetlands be adopted for that meeting, focusing on the freshwater diversion above Head of Passes on the Mississippi River.

120. Dr. Krone suggested reviewing the San Francisco LTMS study in about one year.

121. A decision on the next meeting will await the expected invitation from the New Orleans District and any others that express an interest.

#### 122. Consultants' Comments

- a. *Mr. Simmons.* Mr. Simmons said that this was one of the most interesting CTH meetings he has ever attended. He commended the speakers for their excellent presentations and visual aids. He expressed delight in the progress in numerical modeling; it has fulfilled its earlier promise. Field verification of numerical models is still needed, and comparison to physical models will help improve confidence in the results. For example, a 50-ft channel was tested in the Delaware River physical model, and those results are available in the WES files. Mr. Simmons noted that at an early Coastal Engineering Research Board meeting, GEN Woodbury said that environmental considerations would eventually dictate the well-being of the USACE. He was right.
- b. *Dr. Krone.* Dr. Krone agreed that the last few CTH meetings have demonstrated the maturing of numerical modeling technology. He noted the desirable trend of using numerical technology to provide decision support for environmental hydraulics questions. It provides the ability to obtain a database of model output that District offices can use to evaluate alternatives. Environmental concerns have changed. Two water quality factors are now central to WES Hydraulics Laboratory work—salinity and suspended solids—and the next step is to consider contaminants associated with sediments. WES should start work soon on

developing that capability. Wetlands restoration and development will continue to grow in importance. Since the foundations of wetlands management lie in hydraulics and sedimentation, further development of applicable tools should be encouraged. Dr. Krone said that this was a very enjoyable meeting, and he was delighted to have attended.

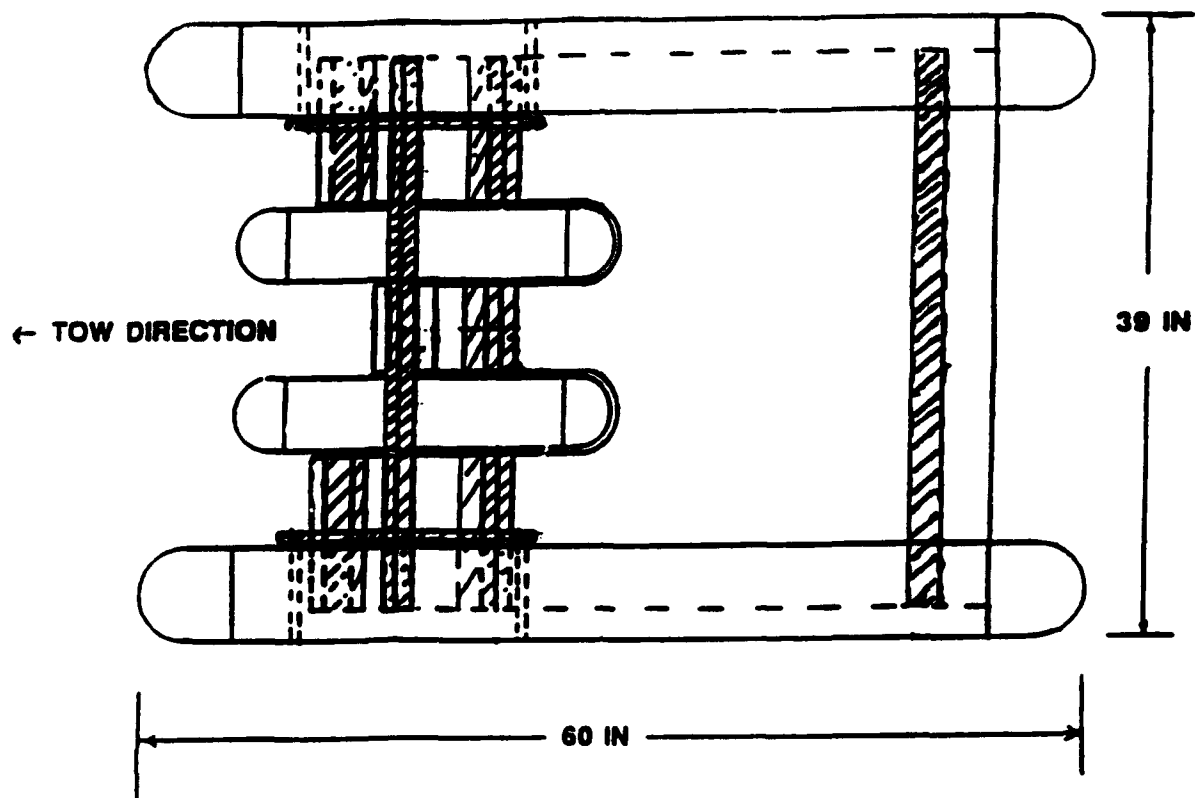
- c. *Dr. Pritchard.* Dr. Pritchard endorsed the comments of Simmons and Krone, and added that he was very impressed with the fabulous graphical displays and animation of numerical model results. The ESTEX design committee should prepare a prioritized list of expected uses and select a cutoff point in trying to design capabilities. To try to do everything will be too costly. For the San Francisco LTMS, he urged an observational program using ADCP equipment and enlisting the participation of other agencies' for simultaneous measurements. WES should be sure to acquire other agencies' ADCP measurements, particularly in the East River.

123. **Adjournment.** Having no other business before it, the 102nd Meeting was officially adjourned by Mr. Herrmann at 12:14 p.m. on 2 September 1993.

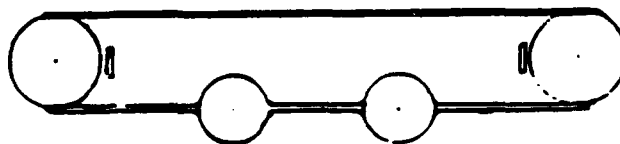
#### 7 Enclosures

1. Schematic drawing of an instrument sled for measuring fluid mud density
2. Plot of pre- and post-dredging depths for Calcasieu Channel obtained with the sled
3. Plot of pre- and post-dredging acoustic depths for Calcasieu Channel
4. List of the Wetlands Research Program tidal demonstration sites
5. Plan views of the ESTEX flume design
6. Flow characteristics of the ESTEX flume
7. ESTEX recommendations from Dr. R. B. Krone

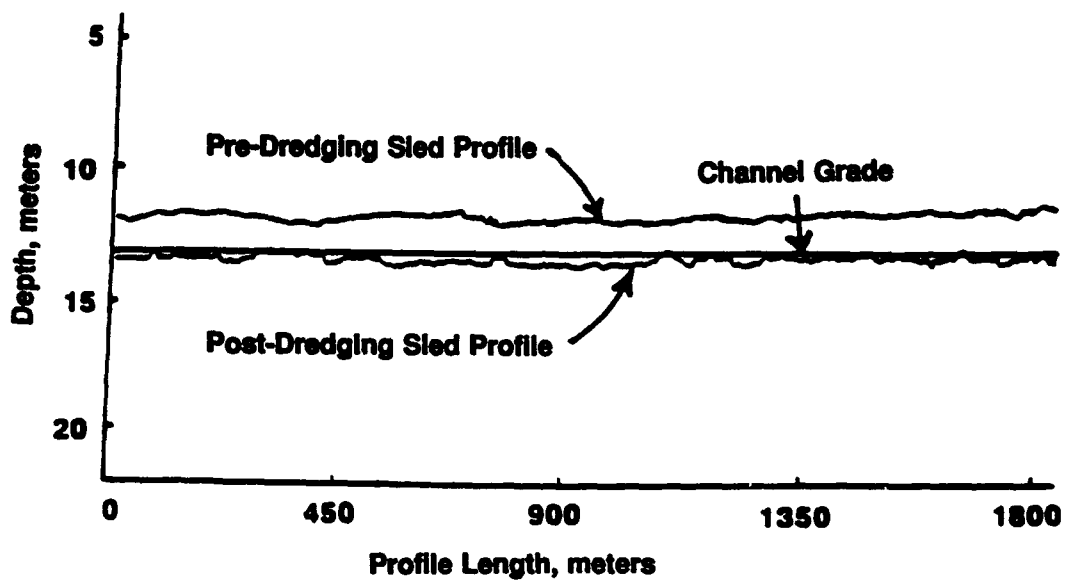
# TOP VIEW



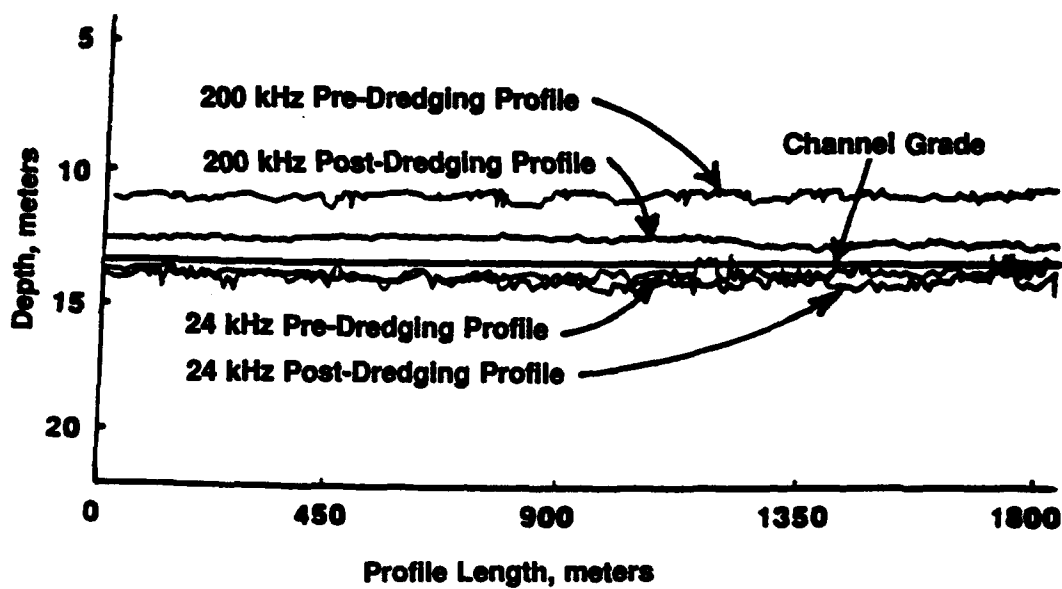
# FRONT VIEW



Schematic drawing of the sled showing front and top views



Pre- and post-dredging sled depths for Calcasieu Channel 1991

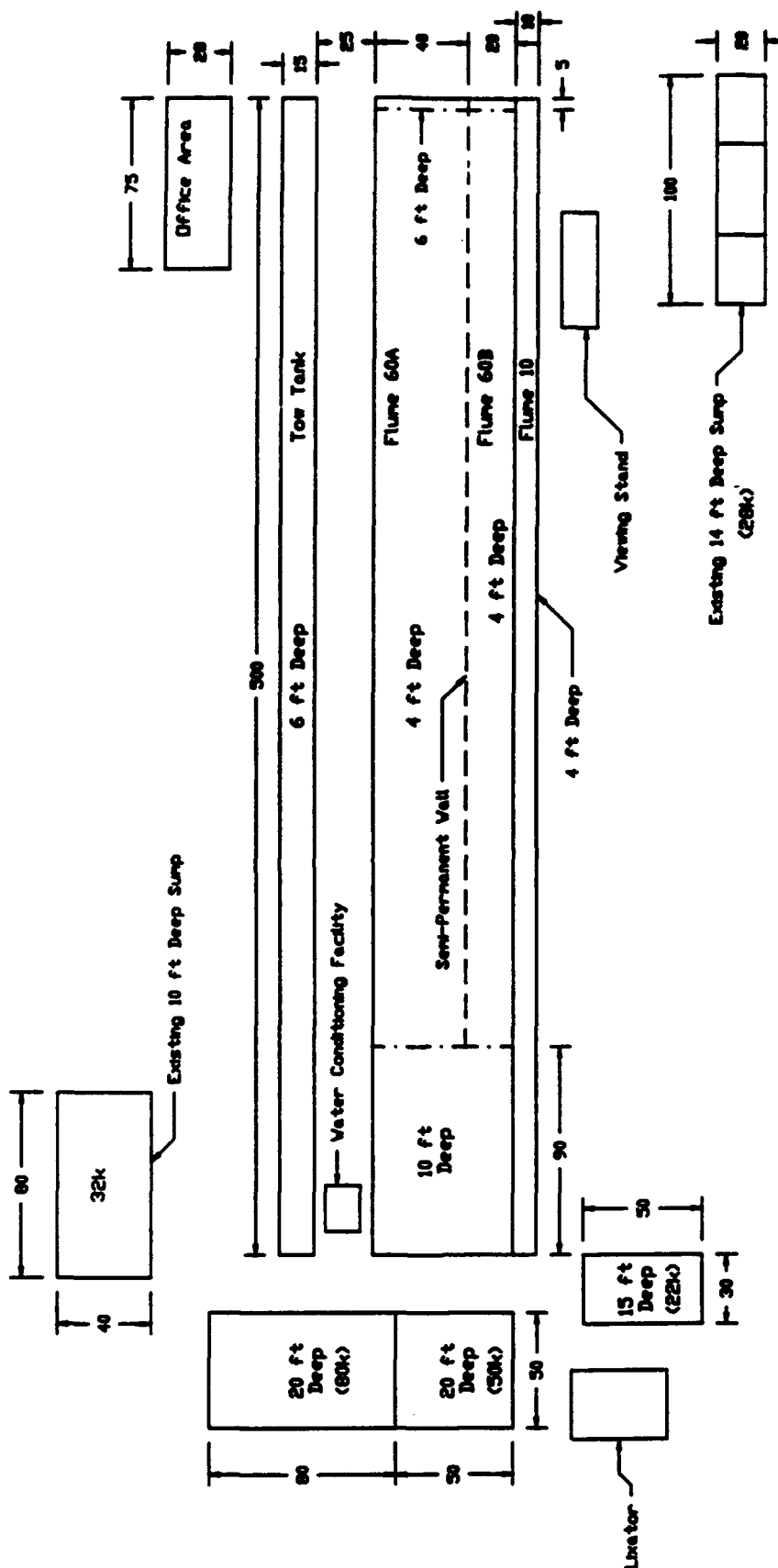


Pre- and post-dredging acoustic depths for Calcasieu Channel 1991

**WETLANDS RESEARCH PROGRAM  
TIDAL DEMO SITES**

- Alabama, Coffee Island, Mississippi Sound (SAM) - Comparison of Manmade vs. Natural Wetlands
- California, Hamilton Antenna Field/San Francisco Bay (SPS) - Comparison of Manmade vs. Natural Wetlands
- Georgia, Buttermilk Sound, Altamaha River (SAS) - Comparison of Manmade vs. Natural Wetlands
- Louisiana, Fina la Terre Marsh Management (LMN) - Wetlands Engineering in Coastal Louisiana
- Louisiana, Lower Miss. River Delta Splays (LMN) - Wetlands Engineering in Coastal Louisiana
- Louisiana, Naomi/West Point Siphon Study (LMN) - Wetlands Engineering in Coastal Louisiana
- Louisiana, Southwest Pass Marsh Nourishment (LMN) - Wetlands Engineering in Coastal Louisiana
- Maryland, Aberdeen Proving Grounds (NAB) - Comparison of Manmade vs. Natural Wetlands
- Maryland, Bodkin Island/Chesapeake Bay (NAB) - Coastal Shoreline and Channel Protection
- Michigan, Lake Erie, Point Mouillee (NCE) - Comparison of Manmade vs. Natural Wetlands
- North Carolina/South Carolina, Winyah Bay/NMFS MOA Comparison Study (SAC/SAW) - Coastal Intertidal Wetland Restoration
- Oregon, Miller Sands/Lower Columbia River (NPP) - Comparison of Manmade vs. Natural Wetlands
- Rhode Island, Galilee Sanctuary (NED) - Coastal Shoreline and Channel Protection
- South Carolina/North Carolina, Winyah Bay/NMFS MOA Comparison Study (SAC/SAW) - Coastal Intertidal Wetland Restoration
- Texas, Aransas NWR Study/West Bay Study (SWG) - Coastal Shoreline and Channel Protection
- Texas, Galveston Bay/Bolivar Peninsula (SWG) - Coastal Intertidal Wetland Restoration
- Washington, Lincoln Avenue, Puget Sound (NPS) - Coastal Intertidal Wetland Restoration

# Plan View of ESTEX Flume Design All Dimensions in Feet





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**Table 1. Flow characteristics of Flume 10**

Manning's  $n=0.015$   
490 ft length of reach  
10.0 ft channel width

Upstream Depth (ft)	Downstream Depth (ft)	Volume Flows (CFS)	Froude Number	Reynolds Number	Speed (fps)
3.0	2.99	20.4	0.07	$1.3 \times 10^5$	0.68
3.0	2.98	28.7	0.10	$1.8 \times 10^5$	0.96
3.0	2.97	35.0	0.12	$2.2 \times 10^5$	1.2
3.0	2.96	40.2	0.14	$2.5 \times 10^5$	1.3

**Table 2. Flow characteristics of Flume 60B**

Manning's  $n=0.015$   
490 ft length of reach  
20.0 ft channel width

Upstream Depth (ft)	Downstream Depth (ft)	Volume Flow (cfs)	Froude Number	Reynolds Number	Speed (fps)
3.0	2.99	51.7	0.09	$2.0 \times 10^5$	0.86
3.0	2.98	72.7	0.12	$2.8 \times 10^5$	1.2
3.0	2.97	88.4	0.15	$3.4 \times 10^5$	1.5
3.0	2.96	101	0.17	$3.9 \times 10^5$	1.7

**Table 3. Flow characteristics of Flume 60A**

Manning's  $n=0.015$   
400 ft length of reach  
40.0 ft channel width

Upstream Depth (ft)	Downstream Depth (ft)	Volume Flow (cfs)	Froude Number	Reynolds Number	Speed (fps)
3.0	2.99	112	0.10	$2.4 \times 10^5$	0.93
3.0	2.98	157	0.13	$3.4 \times 10^5$	1.3

**TABLE 4. Arrested Saline Wedge Characteristics**

Site	Depth (ft)	Q (cfs)	Intrusion Length (ft)	Width Depth Ratio	Densimetric Froude Number	Densimetric Reynolds Number
Flume 10	1	5	112	10	0.6	82,000
Flume 10	2	10	252	5	0.4	230,000
Flume 10	3	20	414	3 1/3	0.4	430,000
MS. River SWP	45	100,000	74,000	33	0.3	23,000,000
Salinity Flume *	0.5	0.02	100	1.5	0.1	26,000

\* Test 11 (partly mixed) reported in Ippen and Harleman (1961)

RAY B. KRONE & ASSOCIATES  
SEDIMENTATION • TIDAL HYDRAULICS

September 14, 1993

Mr. William H. McNally, Jr.  
Chief, Estuaries Division  
Hydraulics Laboratory  
USAE Waterways Experiment Station  
3909 Halls Ferry Road  
Vicksburg, MS 39180-6199

Subject: ESTEX Flumes

Dear Bill:

I promised some written suggestions on the design of the ESTEX flumes at the 102nd CTH meeting. Here they are. The suggestions are based on my experience with five different flumes, two of which I had a hand in designing. As you know, a flume can be a versatile, valuable laboratory facility that enables hydraulic measurements in simple geometry and with controlled temperature, density, and sediment composition. Its versatility can be severely limited, however, by selection of unsatisfactory dimensions, pumps, inlet and outlet works, sediment handling equipment, and instrumentation. The following suggestions are offered with aim toward a design that most likely anticipates the needs of future applications.

1. Prepare a prioritized list of foreseeable future applications with a brief description of the set of experiments in each application. This list will provide a basis for selecting design details and will be useful in preparing proposals for funding. It may not be possible to design a facility that meets all needs, and such a list will provide an opportunity to select design details that meets the most desired needs. You may wish to canvas potential users, or users who have had experience with flumes, to enlarge this list.

2. The dimensions that you described at the CTH meeting appeared to provide flexibility. The most important aspect of the dimensions is the channel width to water depth ratio. Except for strongly stable density profiles, the width to depth ratio should be large to reduce the effects of sidewalls on flows. A major area for future research is the effects of secondary currents on transport and mixing -- in both unidirectional and oscillatory flows. Secondary currents in flumes are strongly affected by the presence of sidewalls, and some very un-natural erosion and deposition patterns have resulted from low width to depth ratios. Because of the simple geometry of a flume, the width to depth ratios of estuaries and rivers need not be reproduced.

I managed with a flume having a ratio of 3:1, but was uncomfortable with it. A ratio of 5:1 or greater is desirable. Determine the water depth needed for measurement of velocity and concentration profiles with desired accuracy and multiply it by 5 or more. Widening it further

makes it possible to study flows around objects, such as bridge piers and abutments, without undesirable influence due to sidewalls.

3. Increasing the width of the channel increases the difficulty in creating uniform flow across the channel. Inlet and outlet configurations need to be designed to distribute the flow as uniformly as possible. We have had the most success using vertical inlets and outlets with the return lines located under the channel.

4. If cohesive sediment transport studies are contemplated, the return pump should have an axial flow impeller and be located at the downstream end of the channel. The pump should be equipped with a variable speed drive that has feedback control to assure constant speed. Two or more return lines should be provided with gate or other low resistance valves near the pump, and the lines should have the minimum number of bends (two). By making the return lines different sizes and selecting one or a combination of lines, the velocity gradients and shear stresses in the lines can be kept within ranges that preclude deposition in the lines while not disrupting suspended aggregates.

The capacity of the pump(s) will depend on the applications planned. For cohesive sediment studies, it would be nice to be able to resuspend deposited sediment by high flows that create bed stresses of 10 dynes/sq cm or more. If such a capacity can not be provided, it will be necessary to suspend the material mechanically by a rototiller-like device (or the Chinese "River Dragon").

5. Sediment studies in large flumes require access by trucks, skip loaders, and small tractors. Either a gate in the side of each channel or a removable ramp should be planned. A gate is much more convenient, but requires effective seals.

6. One or more instrument carriages mounted on really flat rails fastened to the channel sides together with precise means of determining the slope of the tilting channel should be provided for determining surfaces of water and sediment and for mounting velocity probes, etc.

7. If noncohesive sediment studies are contemplated, sediment feeders near the upstream end and a means of removing bed material at the downstream end are needed. The feeder should be designed to feed uniformly across the channel.

8. As I recall, your design included sumps for storing water while the flumes are drained. Such storage is especially important when working with salt water. Means for draining the storage facilities to waste and for cleaning them are recommended.

The large enclosed shelter that you have is a major asset for the proposed flumes. You will find that the establishment of uniform flow and transport over a sediment bed is difficult, and the ability to construct a long sheltered channel provides a greater opportunity to

W. H. McAnally  
9-14-93

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establish such flows than has been possible in conventional laboratory facilities.

Lots of luck! Call if I can help.

Best regards,

*Ray*

Ray B. Krone

W. H. McAnally  
9-14-93

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Enclosure 7  
Sheet 3 of 3